2:2 Cell Parts and Their Jobs

PREPARATION

Materials Needed

Make copies of the Skill, Study Guide, Application, Reteaching, and Lab worksheets in the *Teacher Resource Package*.

▶ Have methylene blue stain and gather *Elodea* and toothpicks for Lab 2-2.

Key Science Words

cell membrane	ribosome
nucleus	mitochondria
nuclear membrane	vacuole
nucleolus	centriole
chromosome	chloroplast
cytoplasm	cell wall

Process Skills

In Lab 2-2, students will observe, compare, and use a microscope.

1 FOCUS

▶ The objectives are listed on the student page. Remind students to preview these objectives as a guide to this numbered section.

MOTIVATION/Bulletin Board

Make a bulletin board showing the parts of an animal cell and a plant cell. As each cell part is studied, identify the part by placing its label on the bulletin board.

Guided Practice

Have students write down their answers to the margin question: cytoplasm.

✓ ASSESSMENT

Oral: Ask students what would happen to a cell if the nucleus became damaged. (The cell would no longer function correctly because the nucleus controls all the activities of the cell.)

2:2 Cell Parts and Their Jobs

Objectives

4. **List** the parts of the cell.
5. **Describe** the functions of the cell parts.

Key Science Words

cell membrane
nucleus
nuclear membrane
nucleolus
chromosome
cytoplasm
ribosome
mitochondria
vacuole
centriole
chloroplast
cell wall

Cells are microscopic units that make up all living things. Cells are alive. They do everything needed to stay alive. They carry on cellular respiration. They grow and reproduce. A cell has many different parts to do all of these jobs. As you study the parts of the cell, refer to Figure 2-7. Figure 2-7 shows an animal cell and a plant cell and the cell parts of each.

Cell Membrane and Nucleus

All cells are surrounded by a cell membrane. The **cell membrane** gives the cell shape and holds the cytoplasm. It also helps control what moves into and out of the cell.

The **nucleus** is the cell part that controls most of the cell's activities. It determines how and when proteins will be made. Proteins are complex substances with several different jobs. Some form cell parts. Others regulate activities of the cell. The nucleus also passes traits from parents to offspring.

The **nuclear membrane** is a structure that surrounds the nucleus and separates it from the rest of the cell. The nuclear membrane has openings that allow certain materials to move into and out of the nucleus.

Inside the nucleus is a smaller body called the nucleolus (new KLEE uh lus). The **nucleolus** is the cell part that helps make ribosomes (RI buh sohmz). You will read about ribosomes in the next section. Some cells have more than one nucleolus.

Also inside the nucleus are threadlike structures called chromosomes (KROH muh sohmz). **Chromosomes** are cell parts with information that determines what traits a living thing will have. Examples of traits are hair color, eye color and sizes and shapes of leaves.

Cytoplasm

What is found between the cell membrane and the nucleus?

The clear, jellylike material between the cell membrane and the nucleus that makes up most of the cell is called **cytoplasm** (SITE uh plaz um). Most of the cell's chemical reactions take place in the cytoplasm. Cytoplasm is mostly water, but it also has other chemicals. In addition, other cell parts that carry on special functions are found in the cytoplasm.

OPTIONS

Science Background

The nucleus determines which proteins will be made and when. Proteins, in turn, regulate most of the other chemical processes in the cell. In this way, the nucleus controls cell activity. Not all cells have nuclei. The red blood cells of mammals have nuclei when they are first formed, but they lose their nuclei before they enter the bloodstream.

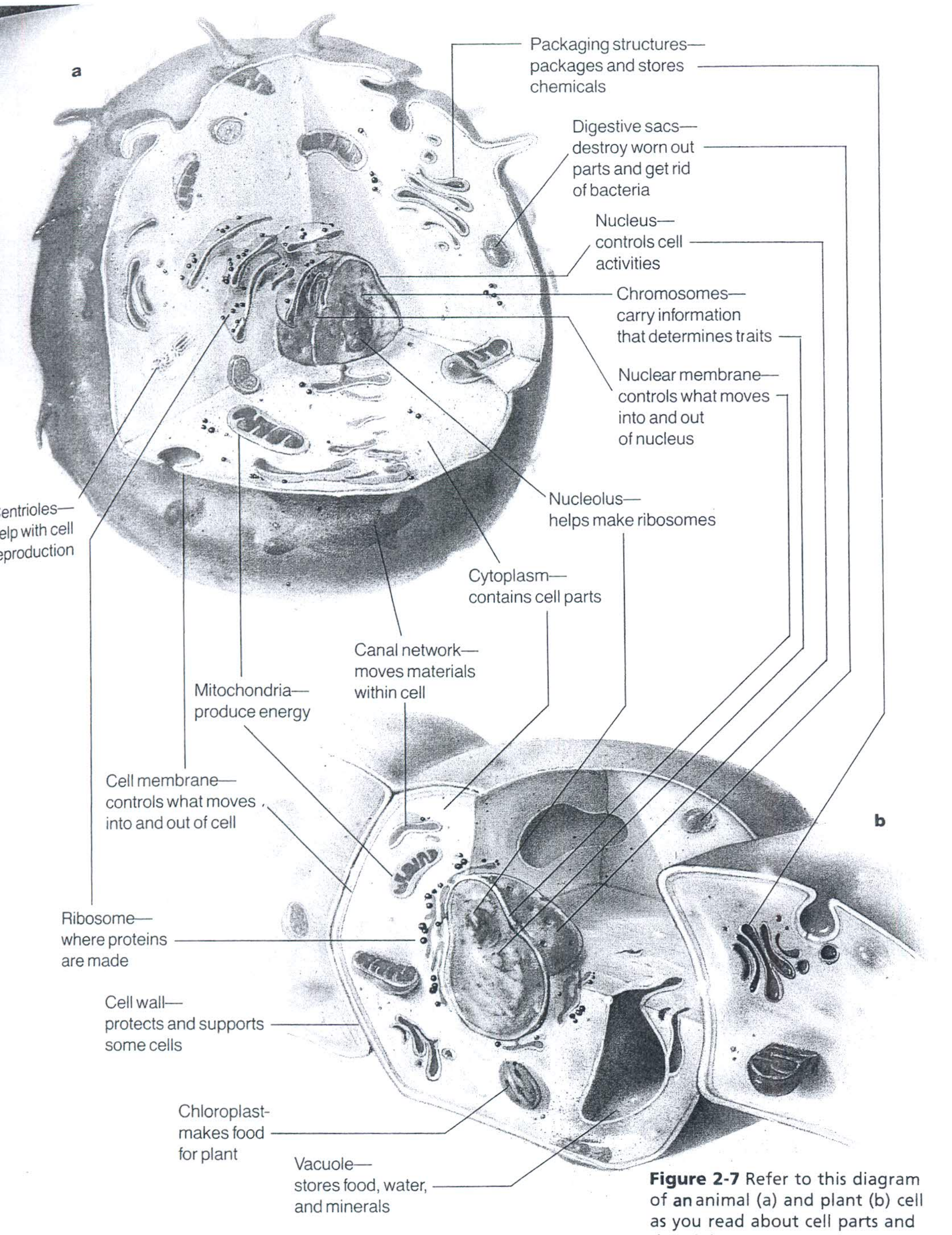


Figure 2-7 Refer to this diagram of an animal (a) and plant (b) cell as you read about cell parts and their jobs.

SKILL 2

SKILL: INTERPRET DIAGRAMS CHAPTER 2

Name ______________ Date ________ Class ________

For more help, refer to the Skill Handbook, pages 706-711. *Use with Section 2:2.*

PLANT AND ANIMAL CELLS

Diagrams in a textbook give information just as words do. They help make the meanings of words clear. Studying Figure 2-7 will help you understand Section 2:2

Use Section 2:2 and Figure 2-7 to complete the table below

In the first column, list all the words in Section 2:2 that are printed in bold type. In the second column, tell where in the cell each cell part is located. In the third column, list the function(s) of each cell part

Cell part	Location	Function(s)
cell membrane	around the cell	gives the cell shape, controls what moves into and out of the cell
nucleus	near the center	controls most of the cell's activities
nuclear membrane	around the nucleus	allows materials to move into and out of the nucleus
nucleolus	in the nucleus	makes ribosomes
chromosomes	in the nucleus	determine what traits a living thing will have
cytoplasm	throughout the cell	makes up most of the cell
ribosomes	in the cytoplasm	where proteins are made
mitochondria	in the cytoplasm	produce energy
vacuole	in the cytoplasm	stores food, water, and minerals
centrioles	in the cytoplasm	help cell reproduction
chloroplasts	in the cytoplasm of plant cells	trap energy for food making
cell wall	surrounds the plant cell	protects and supports the plant cell

OPTIONS

Plant and Animal Cells/*Transparency Package*, number 2a. Use color transparency number 2a as you teach the parts of cells.

Skill/*Teacher Resource Package*, p. 2. Use the Skill worksheet shown here for students to interpret diagrams of plant and animal cells.

2 TEACH

MOTIVATION/Software

The Cell: Examination, Structure, and Function, Queue, Inc.

MOTIVATION/Demonstration

Use a projector to show cell parts of both a plant and an animal cell. Prepared slides of frog blood and onion root tip are usually available.

TEACH

Concept Development

▶ Some students may believe a cell wall and a cell membrane to be the same structure. Distinguish between the two, and continue to reinforce the difference as cells are studied.

▶ Explain that a cell wall does not determine what may enter or leave a cell.

▶ Point out that cells of fungi and some one-celled organisms also have cell walls.

▶ Explain that chromosomes carry the hereditary information from one generation of cells to the next.

Cooperative Learning: Divide the class into cooperative groups of six. Have each group be responsible for learning the functions of two cell parts. Once each group has learned its cell parts, have the groups reshuffle and form new groups. Each person in the new group is responsible for explaining the functions of the cell parts he or she has become an "expert" on.

Student Journal

Students should research the work of Ernest E. Just and write a report on his contributions to the study of cell parts.

TEACH

Concept Development

▶ Explain that cytoplasm consists of many types of proteins and other large molecules.

▶ Point out that mitochondria are most numerous in cells that are active in some way, such as muscle cells and liver cells. In plants, mitochondria are numerous in cells that transport water against the force of gravity.

Idea Map

Have students use the idea map as a study guide to the major concepts of this section.

Guided Practice

Have students write down their answers to the margin question: They are the cell parts where proteins are made.

GLENCOE TECHNOLOGY

Videodisc

The Secret of Life

Animal Cell

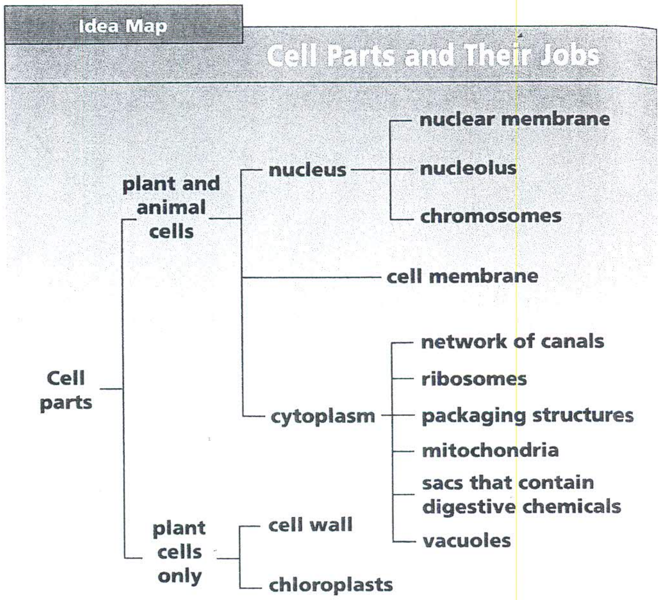
Plant Cell

The Nucleus

Ribosomes

Study Tip: Use this idea map as you study cell parts and their jobs. Remember that only plant cells have cell walls and chloroplasts, and only animal cells have centrioles. All cells have the other cell parts shown in the idea map.

Idea Map



First, the cytoplasm contains a network of canals that help move material around inside the cell. The canals connect the nuclear membrane and the cell membrane.

What is the job of the ribosomes?

A second cell part found in the cytoplasm is the ribosome. **Ribosomes** are cell parts where proteins are made. Large numbers of ribosomes can be found along the canal network, where they are made. Ribosomes can also be found throughout the cytoplasm.

A third cell part found in the cytoplasm is a structure that packages and stores chemicals to be released from the cell. Large numbers of these packaging structures are found in cells that make saliva. Why do you suppose this is so? Large amounts of saliva are needed to break down the foods you eat.

Fourth, the cytoplasm contains rod-shaped bodies called mitochondria (mite uh KAHN dree uh). The **mitochondria** are cell parts that produce energy from food that has been digested. Mitochondria are often called "powerhouses" of the cell because they produce so much energy.

Small sacs that contain digestive chemicals are a fifth structure found in the cytoplasm. The chemicals made in these sacs break down large molecules. They get rid of

Bio Tip

Health: Hair is not made of cells. It is made of protein that is secreted by hair follicle cells. Hair follicle cells surround the root of the hair.

OPTIONS

What Cell Parts Can You See With the Microscope?/*Lab Manual,* pp. 13-16. Use this lab as an extension to studying the parts of cells.

disease-causing bacteria that enter the cell. They also destroy worn-out cell parts and form products that can be used again.

Sixth, most cells have vacuoles (VAK yuh wolz) within the cytoplasm. A **vacuole** is a liquid-filled space that stores food, water, and minerals. Vacuoles also store wastes until the cell is ready to get rid of them. In most plant cells, the vacuole takes up a large amount of space within the cell. The fluid inside the vacuole helps to support the plant.

Centrioles (SEN tree olhz), a seventh structure within the cytoplasm, are located near the nucleus in animal cells but not in plant cells. **Centrioles** are cell parts that help with cell reproduction. They exist in pairs in the cell.

The cytoplasm of plant cells contains an eighth cell part, chloroplasts (KLOR uh plasts). **Chloroplasts** are cell parts that contain the green pigment, chlorophyll. Chlorophyll traps energy from the sun. Plants use this energy to make food. Chloroplasts give plants their green color.

The cells of plants, algae, fungi, and some bacteria have cell walls. Animal cells do not have cell walls. The **cell wall** is a thick outer covering outside the cell membrane. It protects and supports the cell.

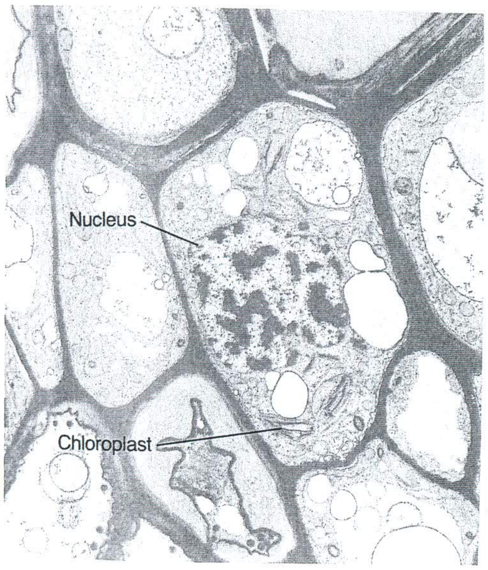
The cell wall often remains after the rest of the cell has died. Wood is made of the walls of dead cells. What did Robert Hooke see when he looked at cork cells?

Skill Check

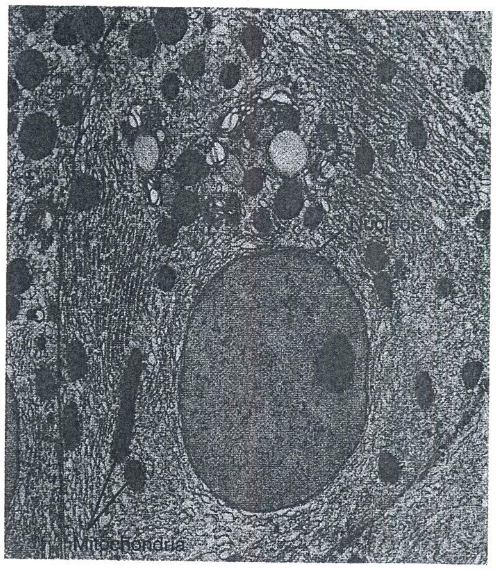
Understand science words: chloroplast. The word part *chloro* means green. In your dictionary, find three words with the word part *chloro* in them. *For more help, refer to the* ***Skill Handbook****, pages 706-711.*

Figure 2-8 A plant cell magnified about 5000 times (a) and an animal cell magnified about 1900 times (b) are shown here. Note the labeled structures.

a



b



TEACH

Concept Development

▶ Explain that in unicellular org isms, food may be digested wit certain vacuoles.

Check for Understanding

Use the overhead projector an transparency of a typical cell to po out each cell part and where i located in the cell. Have stude identify each part and give its fu tion.

Reteach

Write the function of each cell p on a 3 x 5 card. Have a student dr a card, read the function, name t cell part, and tell where the cell p is located in the cell.

Independent Practice

Study Guide/*Teacher R source Package*, p. 9. Use t Study Guide worksheet shown at t bottom of this page for independe practice.

GLENCOE TECHNOLOGY

Videotape

The Secret of Life

What's in Stetter's Pond: The Basics of Life

APPLICATION 2

APPLICATION: ENVIRONMENT — CHAPTER 2

Name ______ Date ______ Class ______

Use after Section 2:2.

A CELL IS LIKE A CITY

To get an idea of how a cell works, compare it to a city. Both a city and a cell act as their own environments, with many parts working together. Parts of the cell are like parts of the city. In some ways, cell parts and city parts are alike in the way they work.

Try to figure out which parts of the cell are like which parts of the city. First, write the functions of the cell parts listed below. Then, look at the list of parts of a city. Think about how each part of the city works. Finally, next to each cell part, write the letter that goes with the part of the city that has the most similar function.

b Cell membrane gives the cell shape and holds in cytoplasm; controls what moves into and out of the cell.

f Nucleus controls most of the cell's activities; determines how and when proteins are made; passes traits from parents to offspring.

d Network of canals helps move material around inside the cell.

g Ribosomes are cell parts where proteins are made.

e Packaging structures package and store chemicals to be released from cell.

a Mitochondria produce energy from food that has been digested.

h Sacs that contain digestive chemicals break down large molecules; destroy bacteria; destroy worn-out cell parts; form new products that can be used again.

c Vacuoles store food, water, and minerals; store wastes until cell gets rid of them.

Parts of a City

a. power plant
b. fence around the city with gates
c. storage company
d. streets
e. packaging center
f. city hall with planning department
g. factories
h. wrecking company

STUDY GUIDE 9

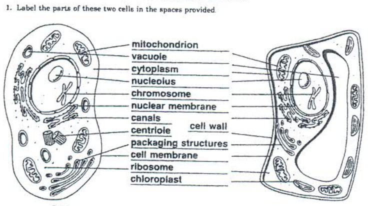
STUDY GUIDE — CHAPTER 2

Name ______ Date ______ Class ______

CELL PARTS AND THEIR JOBS

In your textbook, read about cell parts and their jobs in Section 2:2.

1. Label the parts of these two cells in the spaces provided.



2. Read the descriptions of cell parts below and write in the name of the cell part. Use the color indicated to shade the pictures above.
   a. Use red for the part that gives the cell shape and holds the cytoplasm. cell membrane
   b. Use green for parts that make food. chloroplasts
   c. Use brown for the thick outer covering that protects and supports the cell. cell wall
   d. Use blue for the part that stores substances. vacuole
   e. Use black for parts that get energy from food. mitochondria
   f. Use purple for parts that carry hereditary information. chromosomes
   g. Use pink for the cell part that helps with cell reproduction. centriole
   h. Use orange for the parts that package and store chemicals. packaging structures
3. List two cell parts found only in a plant cell. chloroplasts, cell wall
4. Where in a cell do most chemical reactions take place? in the cytoplasm

OPTIONS

Application/*Teacher Resource Package*, p. 2. Use the Application worksheet shown here to teach how a cell works.

ab 2-2 Cells

ɪverview

ı this lab, students use the light ıicroscope to compare plant and nimal cells. They will stain and bserve cell parts.

ıbjectives: Upon completing this ıb, students will be able to (1) **use a ıicroscope** more efficiently, (2) **pre-ıare** stained cells, (3) **compare** the ıarts of plant and animal cells that re visible with the light microscope.

ime Allotment: 40 minutes

ʼreparation

▶ **Alternate Materials:** Lettuce can ɔe substituted for *Elodea.*

Lab 2-2 worksheet/*Teacher Resource Package*, pp. 7-8.

Teaching the Lab

▶ Caution students to rub their cheeks gently when obtaining cheek cells with the toothpicks. Also instruct them to properly dispose of the toothpick after use.

Cooperative Learning: Have students work in pairs. For more information, see pp. 22T-23T in the Teacher Guide.

▶ **Troubleshooting:** Too many cheek cells on the slide will result in not being able to see the cells.

ASSESSMENT

Performance: Provide students with prepared slides of other plant and animal cells. Ask students to observe the slides under low power and then high power. Students should determine which slides are of plants and which are of animals. Ask students to support their choices.

Cells

Lab 2–2

Problem: How do animal and plant cells differ?

Materials

light microscope
2 glass slides
2 coverslips
dropper
methylene blue stain
toothpick, flat type
Elodea leaf
water

Skills

observe, compare, use a microscope

Procedure

1. Copy the data table.
2. Put a drop of stain on a slide. Gently scrape the inside of your cheek with a toothpick. **CAUTION:** *Do not scrape hard enough to injure your cheek.*
3. Rub the toothpick in the stain. Break the toothpick in half and discard it as your teacher directs.
4. Cover the slide with a coverslip.
5. **Use a microscope:** Look at the cheek cells under low power, then high power.
6. Locate the nucleus, cytoplasm, and cell membrane. Fill in the table by putting a check mark in the box if the cell part can be seen.
7. Draw and label the nucleus, cytoplasm, and cell membrane of a cheek cell.
8. Prepare a slide of an *Elodea* leaf. Put an *Elodea* leaf in a drop of water on a slide. Add a coverslip.
9. Look at the *Elodea* cells under low power, then high power.
10. Locate the cell wall, chloroplasts, nucleus, and cytoplasm. Fill in the table.
11. Draw and label the cell wall, chloroplasts, nucleus, and cytoplasm of an *Elodea* cell.

CELL PART	CHEEK CELL PARTS PRESENT	*ELODEA* CELL PARTS PRESENT
Cytoplasm	√	√
Nucleus	√	√
Chloroplast		√
Cell wall		√
Cell membrane	√	√

Data and Observations

1. Describe the shape of a cheek cell.
2. Describe the shape of an *Elodea* cell.
3. **Compare:** What parts did you see in both cells?
4. What parts are found in plant cells that are absent in animal cells?

Analyze and Apply

1. What do the cell parts found only in plant cells do?
2. Is the nucleus always found in the center of the cell?
3. Which part of an animal cell gives shape to the cell?
4. Which parts of a plant cell give shape to the cell?
5. Why are stains such as methylene blue used when observing cells under the microscope?
6. **Apply:** Why don't animal cells have chloroplasts? (HINT: How do animals get energy?)

Extension

Observe other plant and animal cells under the microscope. How are they different from cheek cells and *Elodea* cells? How are they alike?

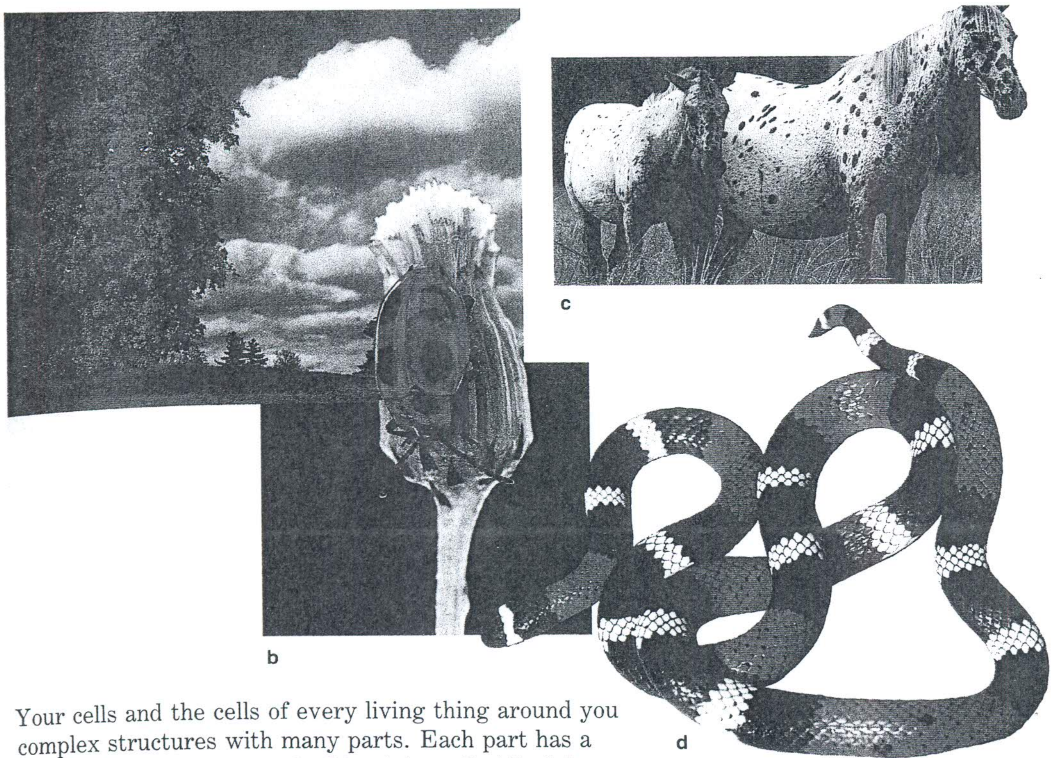
ANSWERS

Data and Observations

1. round and uneven
2. rectangular
3. cytoplasm, nucleus, cell membrane
4. chloroplast, cell wall

Analyze and Apply

1. Chloroplasts trap energy from the sun and make food; the cell wall protects the cell and gives it support.
2. no
3. cell membrane
4. cell wall
5. to make the cell parts visible
6. Animals get energy from the food they eat.



Your cells and the cells of every living thing around you complex structures with many parts. Each part has a ction that is important to the life of the cell. All of the ng things in Figure 2-9 are made of cells. What other ng things can you name that are made of cells?

Figure 2-9 The maple tree (a), ladybug (b), horse (c), and snake (d) are all made of cells.

Check Your Understanding

Which cell part is being described?
(a) helps keep cytoplasm inside
(b) controls most of the cell's activities
(c) a liquid-filled space for storage
(d) green parts of plants that trap energy from the sun
(e) clear, jellylike material in which most of the cell's chemical reactions take place

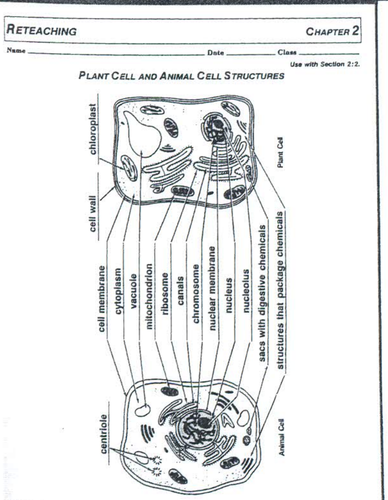
Name two cell parts found in plant cells that are not found in animal cells.

Why are mitochondria called "powerhouses" of the cell?

Critical Thinking: How do mitochondria and chloroplasts differ?

Biology and Writing: Write three sentences describing the cell parts that make up a wooden table.

RETEACHING 5



GLENCOE TECHNOLOGY

Videodisc
The Secret of Life
Diffusion

Osmosis

TEACH

Check for Understanding

Have students respond to the first three questions in Check Your Understanding.

Reteach

Reteaching/*Teacher Resource Package*, p. 5. Use this worksheet to give students additional practice comparing plant cell and animal cell structures.

Extension: Assign Critical Thinking, Biology and Writing, or some of the **OPTIONS** available with this lesson.

3 APPLY

Connection: Language Arts

Have students list the cell parts and use a dictionary to find the origin and meaning of each word.

4 CLOSE

Make a Model

Have students work in pairs with clay and paints to make a model of either a plant or an animal cell.

Answers to Check Your Understanding

6. (a) cell membrane, (b) nucleus, (c) vacuole, (d) chloroplast, (e) cytoplasm
7. cell wall and chloroplast
8. they produce so much energy
9. Chloroplasts trap energy from the sun and change it into food energy. Mitochondria produce energy from food that has been digested.
10. Answers will vary. Students should include cell walls in their answers.

2.1

What Is Matter?

KEY TERMS

chemistry
matter
element
atom
compound
molecule
chemical formula
pure substance
mixture
miscible
immiscible

OBJECTIVES

- Explain the relationship between matter, atoms, and elements.
- Distinguish between elements and compounds.
- Interpret and write some common chemical formulas.
- Categorize materials as pure substances or mixtures.

Making glass, as shown in **Figure 2-1,** involves changing the raw materials sand, limestone, and soda ash into a different substance. This is what **chemistry** is all about: what things are made of and how things change. Everything you use daily, from soap to food to glue, you choose because of chemistry—either because of what it is made of or how it changes.

chemistry the study of matter and how it changes

Glass is used as a building material because its properties of being transparent, solid, and waterproof match the needs we have for windows. The properties of sand, on the other hand, do not match these needs. Chemistry keeps the choices among so many materials from being too confusing because it helps you recognize how the differences in material properties relate to what the materials are made of.

Matter

matter anything that has mass and occupies space

You are made of **matter.** This book is also matter. All the materials you can hold or touch are matter. The air you are breathing is matter, even though you can't see it. Light, sound, and electricity are not matter. Unlike air, they have no mass or volume.

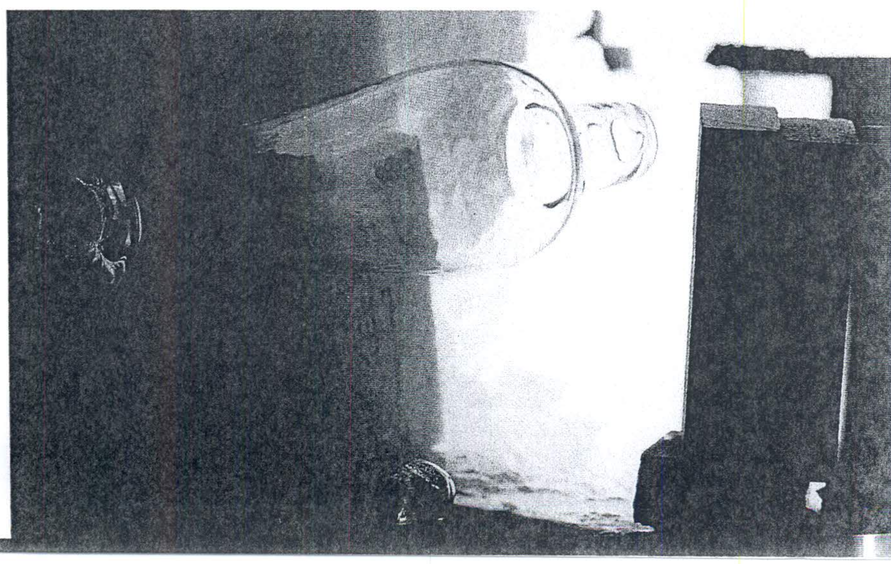


Figure 2-1
Glass blowers have been practicing their craft with few changes for more than 2000 years.

Atoms are matter

Wood is matter. Because it is fairly rigid and lightweight, wood is a good choice for furniture and buildings. When wood gets hot enough, it chars—its surface turns black. The wood surface breaks down to form another kind of material with different properties, carbon. Nothing you can do to the carbon in the charred residue will cause the carbon to decompose. Carbon is an **element**, and elements are made of **atoms.** An image of some iron atoms is shown in **Figure 2-2.**

Diamonds are made of atoms of the element carbon. The shiny foil wrapped around a baked potato is made of atoms of the element aluminum. The elements that are most abundant on Earth and most abundant in the human body are shown in **Figure 2-3.** Each element also has a one- or two-letter symbol used worldwide to designate it. For example, carbon is C, iron is Fe, copper is Cu, and aluminum is Al. Each of the more than 110 elements that we now know is unique and behaves differently from the rest.

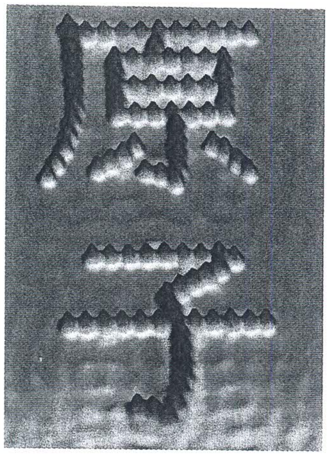


Figure 2-2
This scanning tunneling microscope image shows iron atoms (red) on copper atoms (blue).

element a substance that cannot be broken down into simpler substances

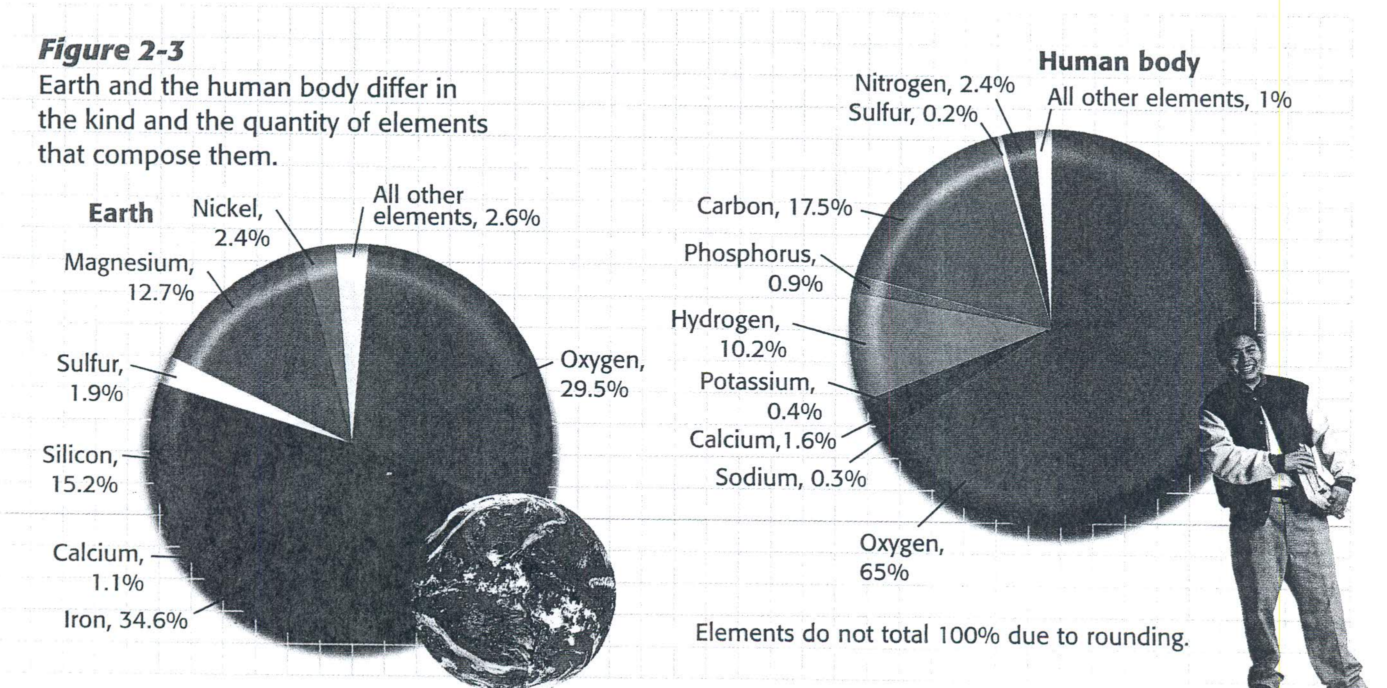
atom the smallest particle that has the properties of an element

compound a substance made of atoms of more than one element bound together

Two or more elements combine chemically to make a compound

Many familiar substances, such as aluminum and iron, are elements. Nylon is another familiar substance, but it is not an element. Nylon is a **compound.** The basic unit that makes up nylon contains carbon, hydrogen, nitrogen, and oxygen atoms, but each strand actually contains hundreds of these units linked together.

Figure 2-3
Earth and the human body differ in the kind and the quantity of elements that compose them.



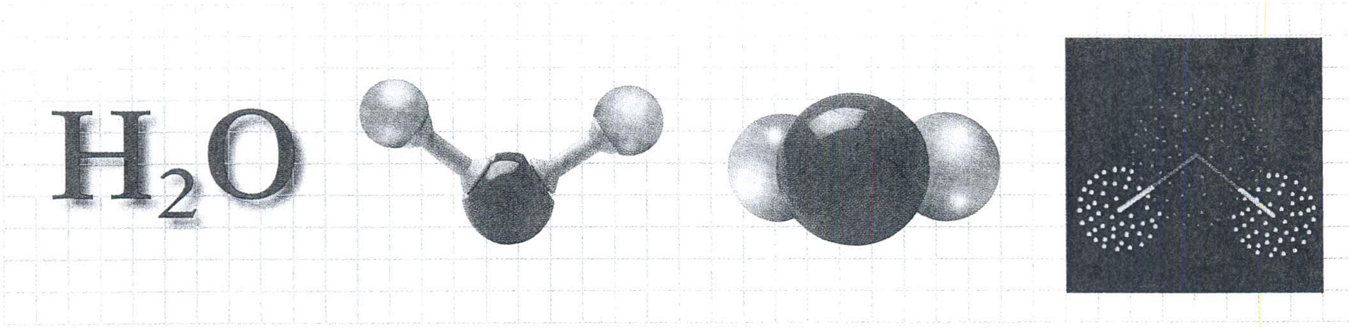


Figure 2-4
A water molecule can be represented as a formula, in physical models, or on a computer.

Every compound is unique and is different from the elements it contains. For example, the elements hydrogen, oxygen, and nitrogen occur in nature as colorless gases. Yet when they combine with carbon to form nylon, the strands of nylon are a flexible solid.

Each unit of iron(III) oxide, which we see often as rust, is made of two atoms of iron and three atoms of oxygen. When elements combine to make a specific compound, the elements always combine in the same proportions. Iron(III) oxide always has two parts of iron for every three parts of oxygen.

molecule the smallest unit of a substance that exhibits all of the properties characteristic of that substance

A molecule acts as a unit

Atoms can join together to make millions of different **molecules** just as letters of the alphabet combine to form different words. A molecular substance you are familiar with is water. A water molecule is made of two hydrogen atoms and one oxygen atom, as shown in **Figure 2-4.**

When oxygen and hydrogen form a molecule of water, the atoms combine and act as a unit. That is what a molecule is—the smallest unit of a substance that behaves like the substance. Most molecules are made of atoms of different elements, just as water is. But a molecule also may be made of atoms of the same element, such as those in **Figure 2-5.** Besides the elements shown in the figure, fluorine, nitrogen, iodine, and bromine form molecules of two atoms. Sulfur forms a molecule of eight atoms, S_8.

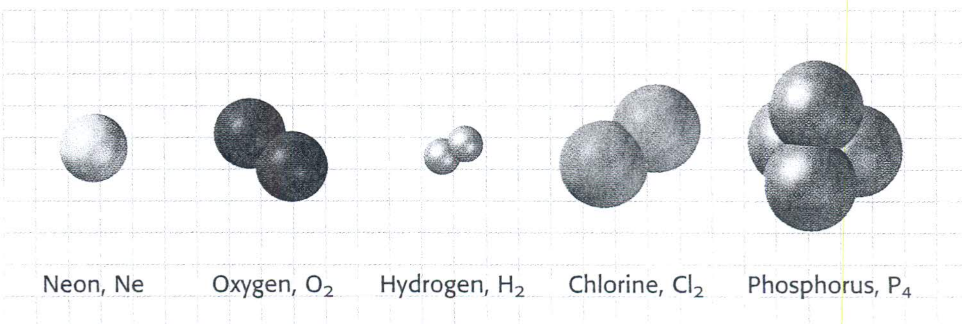
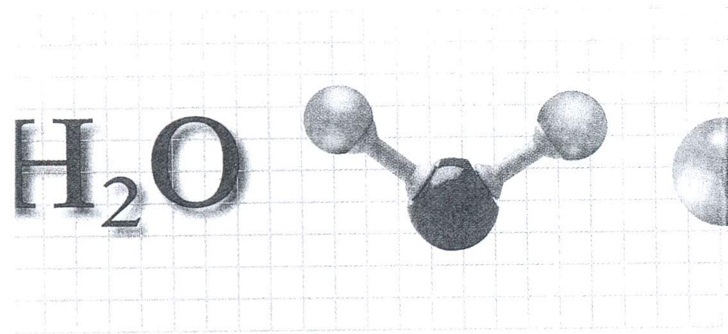


Figure 2-5
The atoms of most elements, such as neon, Ne, are found singly in nature. The atoms of some elements form molecules, such as oxygen, O_2, hydrogen, H_2, chlorine, Cl_2, and phosphorus, P_4.



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Carbon Hydrogen Nitrogen Oxygen

$C_{16}H_{10}N_2O_2$

16 carbon atoms | 10 hydrogen atoms | 2 nitrogen atoms | 2 oxygen atoms

re 2-4
ter molecule can be
sented as a formula, in
cal models, or on a
uter.

Every compound is :om of
it contains. For examprmula
nitrogen occur in nat
combine with carbon tical formula show the
flexible solid. ree molecules of table
Each unit of iron(Ilecule of the sugar con-
made of two atoms of is, and 11 oxygen atoms.
ements combine to ma
ways combine in the s
has two parts of iron fo
ually mean "not mixed

A molecule acts as a untains only the juice of
Atoms can join togethe In chemistry, the word
just as letters of the alptance is matter with a
molecular substance yc
ecule is made of two h is a **mixture** of many
shown in **Figure 2-4.** er, sugars, acids, and
When oxygen and is not fixed; it can have
atoms combine and actor other compounds.
smallest unit of a substances, but mixtures are
molecules are made of e mixtures. The air we
is. But a molecule alsod oxygen.
ment, such as those in lparated. The water in
the figure, fluorine, nugar, acids, and other
ecules of two atoms. Sunot changed by evapo-
ıot be broken down by
or grinding.

mixtures
ements that make it, a
to the pure substances
different substances in
physical properties in
Hple, grape juice is wet
t are in it.

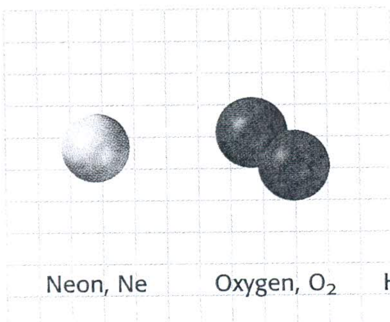
molecule the smallest unit of a substance that exhibits all of the properties characteristic of that substance

Figure 2-6
The chemical formula for a molecule of indigo shows that it is made of four elements and 30 atoms.

chemical formula the chemical symbols and numbers indicating the atoms contained in the basic unit of a substance

pure substance any matter that has a fixed composition and definite properties

mixture a combination of more than one pure substance

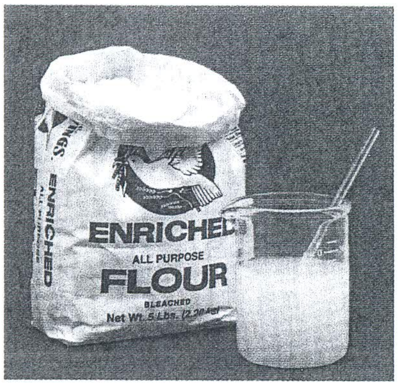


ure 2-5
atoms of most
nents, such as neon,
are found singly in
ure. The atoms of some
nents form molecules,
ı as oxygen, O_2,
rogen, H_2, chlorine, Cl_2,
phosphorus, P_4.

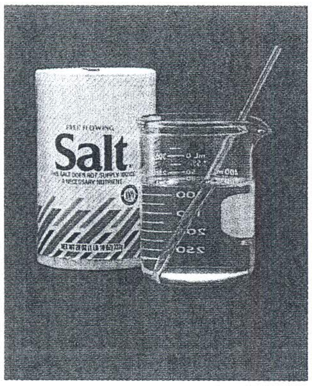
INTEGRATING

BIOLOGY
Indigo is a natural plant dye made from members of the genus *Indigofera,* which is in the pea family. Before synthetic dyes were developed, indigo was widely grown in the East Indies, in India, and in the Americas. Most indigo species are shrubs 1 to 2 m in height. Leaves and branches of the plants are fermented to yield a paste, which is formed into blocks and then finely ground. The blue color develops as the material is exposed to air.

Figure 2-7



A Flour is suspended in water.



B Salt dissolves in water.

Mixtures are classified by how thoroughly the substances mix

Some mixtures are made by putting solids and liquids together. In **Figure 2-7,** two white powdery solids, flour and salt, are each mixed with water. Despite the physical similarities of these solids, the mixtures they form with water are very different.

The flour doesn't mix well with the water, yielding a cloudy white mixture. You can see that flour does not dissolve in water. A mixture of flour and water is called a *heterogeneous mixture* because the substances aren't uniformly mixed.

The salt-and-water mixture looks very different from the flour-and-water mixture. You cannot see the salt, and the mixture is clear. That's because salt dissolves in water. Even if you leave the mixture for a long time, the salt will not settle out. Salt and water yield a *homogeneous mixture* because the mixing occurs between the individual units and is the same throughout.

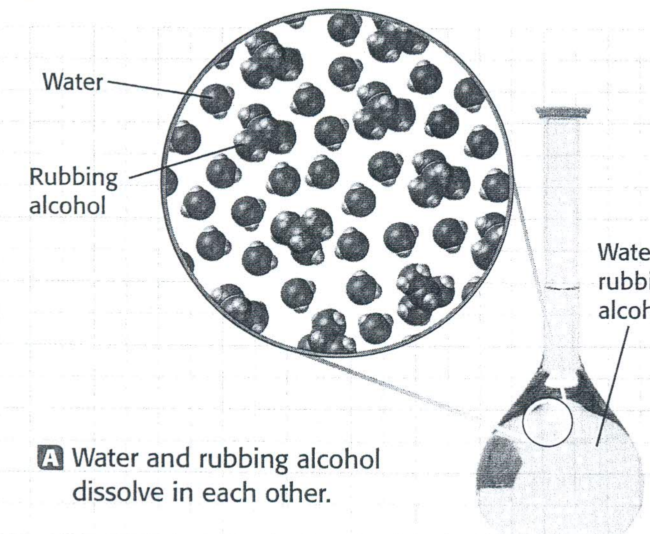
Gasoline is a liquid mixture—a homogeneous mixture of at least 100 compounds in various quantities. Because the compounds are **miscible,** gasoline looks like a pure substance even though it isn't.

If you shake a mixture of oil and water, the water will settle out after a while. Oil and water form a heterogeneous mixture. Because oil and water are **immiscible,** you can see two layers in the mixture. **Figure 2-8** shows examples of liquid mixtures.

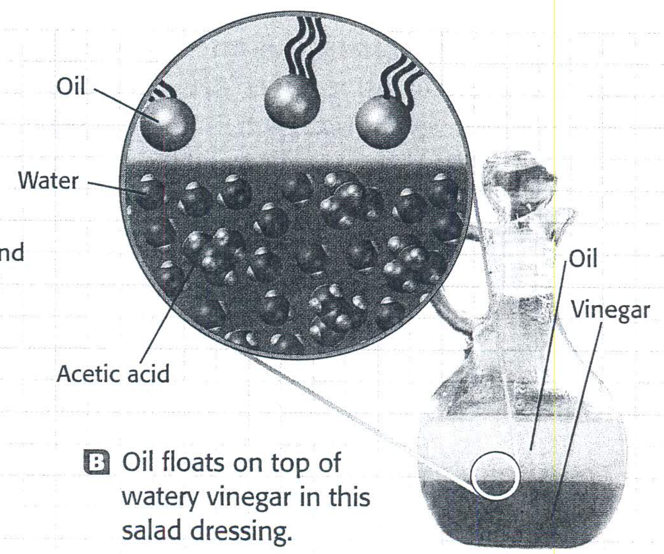
miscible describes two or more liquids that are able to dissolve into each other in various proportions

immiscible describes two or more liquids that do not mix into each other

Figure 2-8 **Examples of Miscible and Immiscible Liquids**



A Water and rubbing alcohol dissolve in each other.



B Oil floats on top of watery vinegar in this salad dressing.

Science and the Consumer

Dry Cleaning: How Are Stains Dissolved?

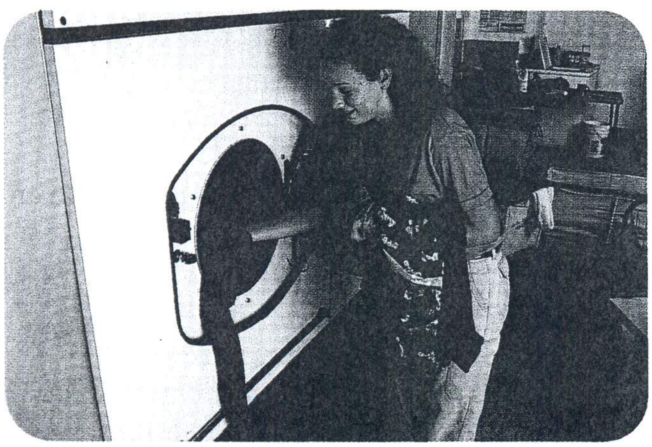
Why do some clothes need to be dry cleaned, while others do not? Washing with water and detergents cleans most clothes. But if your clothes have a stubborn stain—such as ink or rust, if you have spilled something greasy on your clothes, or if the label on the clothing recommends dry cleaning, then dry cleaning may be necessary. Dry cleaning is recommended on a clothing label when the fabric does not respond well to water. Certain fabrics, like silk and wool, are usually cleaned without water because water causes them to shrink, take on stubborn wrinkles, or lose their shape.

Stain Removal

Knowing the composition of a stain helps dry cleaners decide how to treat it. Removing a stain that doesn't dissolve in water, such as oil or grease, involves two steps. First, the stain is treated with a substance that loosens the stain. Then the stain is removed when the garment is washed in a mechanical dry cleaner.

If a stain is water-soluble, it will dissolve in water. A water-soluble stain is first treated with a stain remover that is specific to that stain. The stain is then flushed away with a steam gun. After the garment is dry, it is cleaned in a dry-cleaning machine to remove any stains that do not dissolve in water.

Once the fabric has been treated for tough stains, the garment is washed in a dry-cleaning machine.



Dry Cleaning Isn't Really Dry

In spite of its name, dry cleaning does involve liquids. The process uses a liquid solvent instead of water. It is always difficult to remove fats, greases, and oils from fabrics with water-based washing.

A good dry-cleaning solvent must dissolve oil and grease, which trap the water-insoluble particles in the cloth fibers. The most commonly used dry-cleaning solvent is tetrachloroethylene, C_2Cl_4. Tetrachloroethylene is the preferred solvent because oil, grease, and alcohols dissolve in it. Also, tetrachloroethylene is not flammable, and it evaporates easily. This allows it to be recycled by distillation.

In distillation, the components of a mixture are separated based on their rates of evaporation. Upon heating, the component that evaporates most quickly is the first to vaporize and separate from the mixture. When the vapors are cooled, they condense to form a purified sample of that component.

Tetrachloroethylene is suspected of causing some kinds of cancer. To meet the standards of the United States Occupational Safety and Health Administration (OSHA) and other federal guidelines, dry-cleaning machines must be airtight so that no C_2Cl_4 escapes.

Your Choice

1. **Critical Thinking** Explain why it is difficult to remove fats, greases, and oils from fabrics with water-based washing alone.
2. **Critical Thinking** Tetrachloroethylene evaporates more quickly than the fats, grease, and oils it dissolves. Describe how C_2Cl_4 can be recycled by distillation.

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SCILINKS NSTA

TOPIC: Dry cleaning
GO TO: www.scilinks.org
KEYWORD: HK1022

INTEGRATING

EARTH SCIENCE

The molten rock in some types of volcanoes contains large quantities of gas. Pumice, a solid foam that occurs naturally on Earth, is a volcanic rock formed by the violent separation of these extremely hot gases from lava. As the exploding lava cools, it traps the gas bubbles. Some pumice is so soft that it is spongy, and some is so light that it floats on water. Often pumice occurs as small pea-size lumps, but it also occurs in deposits large enough to be mined and sold commercially as an abrasive.

Gases can mix with liquids

Air is a mixture of gases consisting mostly of nitrogen and oxygen. You get oxygen every time you breathe because the gases in air form a homogeneous mixture. Carbonated drinks are also homogeneous mixtures. They contain sugar, flavorings, and carbon dioxide gas, CO_2, dissolved in water. When carbonated drinks are manufactured, the carbon dioxide gas is mixed into the liquid under pressure and forms a solution.

Even a liquid that is not mixed with gas under pressure can contain dissolved gases. If you let a glass of cold water stand overnight, you may be able to see bubbles on the sides of the glass the next morning. The bubbles are some of the air that was dissolved in the cold water.

Carbonated drinks often have a foam on top. A foam is a different kind of gas-liquid mixture. The gas is not dissolved in the liquid but has formed tiny bubbles in it. Eventually, the tiny bubbles join together to form bigger bubbles that can escape from the foam, and the foam collapses.

Other foams are stable and last for a long time. If you whip egg white with enough air, you get a foam. If you heat that foam in an oven, the liquid egg white dries and hardens, and you have a solid foam—meringue.

SECTION 2.1 REVIEW

SUMMARY

- Matter has mass and occupies space.
- An element is a substance that cannot be broken down into a simpler substance.
- An atom is the smallest particle of matter that has the properties of a particular element.
- Atoms can join together to form molecules.
- A pure substance that contains two or more elements is a compound.
- A pure substance can be represented by a chemical formula.

CHECK YOUR UNDERSTANDING

1. **Define** *chemistry.*
2. **List** the two types of pure substances.
3. **Explain** why light is not matter.
4. **Complete** the following analogy:
   A heterogeneous mixture is to a homogeneous mixture as immiscible liquids are to ________.
5. **Classify** each of the following as an element or a compound:
   a. sulfur, S_8 **c.** carbon monoxide, CO
   b. methane, CH_4 **d.** cobalt, Co
6. **Describe** the makeup of pure water, and write its chemical formula.
7. **Compare and Contrast** mixtures and pure substances. Give an example of each.
8. **Critical Thinking** David and Susan are looking at a jar of honey labeled "Pure Honey." David says, "That means it's natural honey, with nothing else added." Susan says, "It isn't really pure. It's a mixture of lots of different substances." Who is right? Explain your answer. WRITING SKILL

2.2

Matter and Energy

OBJECTIVES

- Use the kinetic theory to describe the properties and structures of the different states of matter.
- Describe the energy transfers involved in changes of state.
- Describe the laws of conservation of mass and conservation of energy, and explain how they apply to changes of state.

KEY TERMS

pressure
viscosity
energy
evaporation
condensation
sublimation

If you go to a bakery, such as the one in **Figure 2-9,** you can smell the cookies baking even though you are a long way from the oven. One way to explain this phenomenon is to make some assumptions. First, assume that the particles (molecules and atoms) within substances can move. Second, assume that the molecules and atoms move faster as the temperature rises. A theory based on these assumptions, called the kinetic theory of matter, can be used to explain things like why you can smell cookies baking from far away.

When cookies are baking, energy is transferred from the oven to the cookies. As the temperature in the oven is increased, some molecules within the cookie dough move fast enough to become gases, which in turn spread through the air in the bakery.

Figure 2-9
The substances that make the fresh cookies smell so good may be vanillin, $C_8H_8O_3$, or cinnamaldehyde, C_9H_8O.

Kinetic Theory

Here are the main points of the kinetic theory of matter.

- **All matter is made of atoms and molecules that act like tiny particles.**
- **These tiny particles are always in motion. The higher the temperature, the faster the particles move.**
- **At the same temperature, more massive (heavier) particles move slower than less massive (lighter) particles.**

The kinetic theory is a useful tool for visualizing the differences between the three common states of matter: solids, liquids, and gases.

Common States of Matter

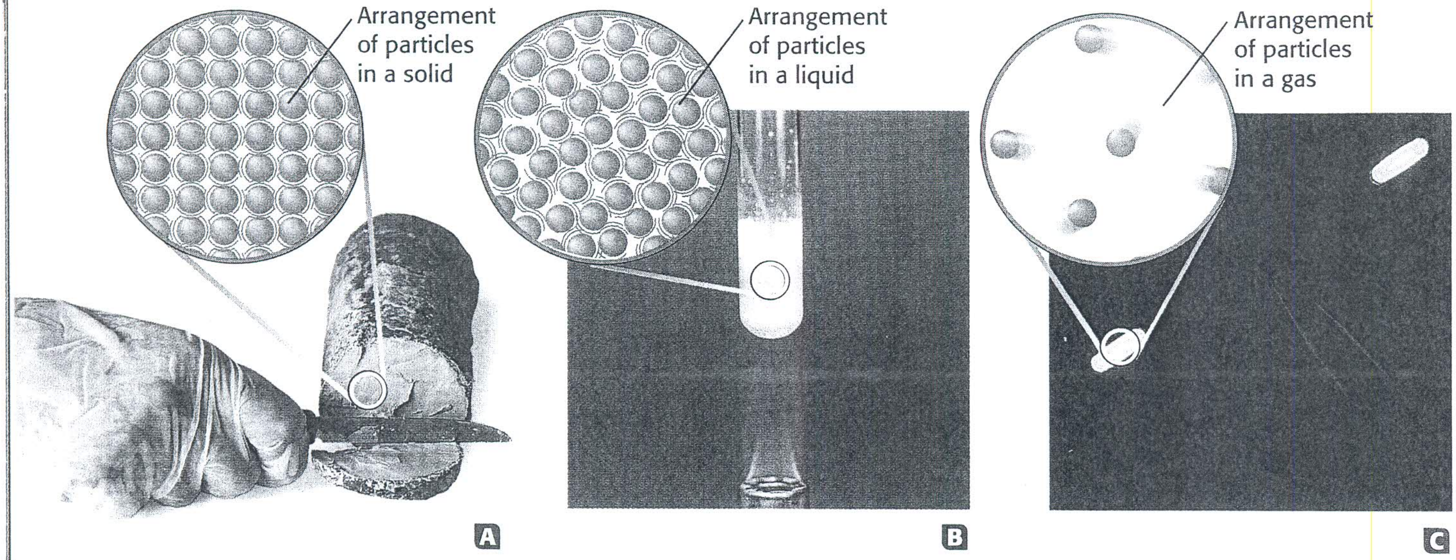


Figure 2-10
Gases, liquids, and solids are the most common states of matter on Earth. Here, the element sodium is shown as (A) the solid metal, (B) melted as a liquid, and (C) as a gas in a sodium-vapor lamp.

The states of matter are physically different

The models for solids, liquids, and gases shown in **Figure 2-10** differ in the distances and angles between molecules or atoms and in how closely these particles are packed together. Gas particles, like those in helium, are in a constant state of motion and rarely stick together. In a liquid, like cooking oil, the particles are closely packed, but they can still slide past each other. Particles in a solid, like iron, are in fixed positions. Most matter found naturally on Earth is either a solid, a liquid, or a gas, but matter also exists in other states.

Did You Know?

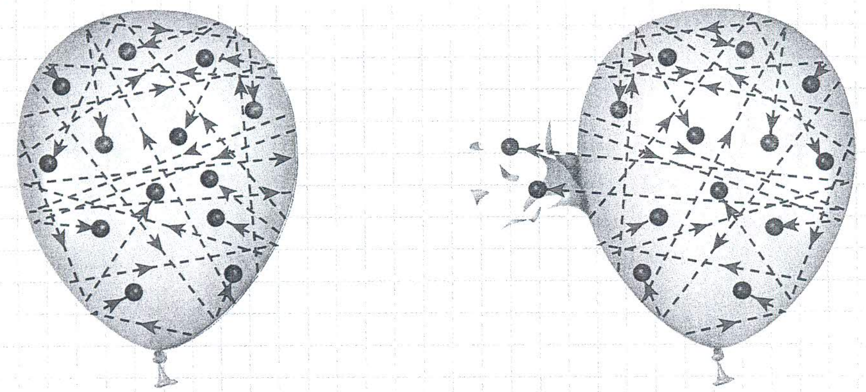
Very dense neutron stars and plasmas are examples of two other generally accepted states of matter. Our sun and most stars are plasmas made of fast-moving charged particles. In the Bose-Einstein condensate, atoms are at temperatures so close to absolute zero that they behave as one atom. This state of matter was first observed in 1995. Einstein predicted it in 1925 when he furthered the calculations of S. N. Bose, an Indian physicist.

Gases are free to spread in all directions

Have you noticed that a balloon filled with a "light" gas such as helium goes flat more quickly than a balloon filled with air? You can use the kinetic theory to explain this. The wall of the balloon has tiny holes through which gas particles can escape. The helium particles are smaller and less massive than the nitrogen and oxygen particles found in air. The smaller and less massive particles move faster, so they get through the holes more quickly.

When you inflate a balloon, the entire balloon expands. This is one of the characteristics of a gas—it expands to fill the available space. Kinetic theory can be used to explain this property as well. Under standard conditions of temperature and pressure, particles of a gas move rapidly. Oxygen, O_2, averages almost 500 m/s, and helium, He, travels at more than 1200 m/s. At these speeds, gas particles collide billions of times a second. Like all particles of gas, helium atoms bounce off each other when they collide. As helium atoms bounce around and move freely, they spread to fill the available space.

Figure 2-11



A Gas particles exert pressure by hitting the walls of a balloon.

B The balloon pops because the internal pressure is more than the balloon can hold.

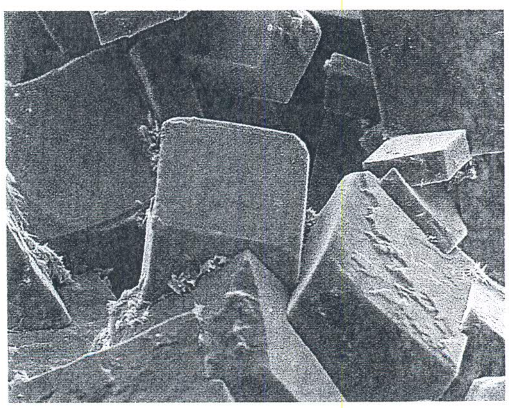
Gases can exert pressure

You may know that a balloon filled with helium is under pressure. The gas in the balloon is pushing out against the balloon walls. The kinetic theory also helps to explain pressure. Helium atoms in the balloon are moving very quickly and are constantly hitting each other and the walls of the balloon, as shown in the model in **Figure 2-11.** Each particle's effect on the balloon wall is tiny, but the battering by millions of particles adds up to a steady force. The pressure inside the balloon is the measure of this steady force. If too many particles of gas are in the balloon, the battering overcomes the force of the balloon holding the gas in, and the balloon pops.

pressure the force exerted on a unit area of a surface

If you let go of a balloon that you've held pinched at the neck, most of the gas inside rushes out, causing the balloon to shoot through the air. Gases under pressure will escape their container if possible. If there is a lot of pressure in the container, the gas can escape with a lot of force. For this reason, gases in pressurized cylinders and similar containers, like propane tanks for gas grills, can be dangerous and must be handled carefully.

Figure 2-12
The particles in these crystals of salt cannot move freely like the particles in a liquid or a gas can. These crystals of sodium chloride have been magnified 840 times.



Solids have a rigid structure

If you take an ice cube out of the freezer and put it on a table, the ice will stay there as long as it remains solid. It has the same volume and shape that it had in the ice tray. Unlike gases, a solid does not need a container to have a shape. This is because the structure of a solid is very rigid, and the particles have almost no freedom to change position. The crystals of salt in **Figure 2-12** reflect the ordered arrangement of particles in most solids. The particles are held closely together by strong attractions, yet they can still vibrate around a fixed location.

Quick ACTIVITY

Kinetic Theory

You will need water, vegetable oil, and rubbing alcohol.

SAFETY CAUTION The alcohol is flammable and toxic.

1. Dip one index finger into the water. Dip your other index finger into the oil. Wave each finger in the air. Do your fingers feel cool? How quickly does each liquid evaporate?
2. Repeat the experiment, using water on one finger and rubbing alcohol on the other.
3. Which of the three liquids evaporates the quickest? the slowest? Which liquid cools your skin the most? the least?
4. Use the kinetic theory to explain your observations.

Liquids take the shape of their container

The particles of a liquid are close together, but they are not attracted to each other as strongly as they are in a solid. So the particles in a liquid have more freedom of movement. Because particles in a liquid can move randomly, liquids can spread out on their own. And because liquids and gases can spread, both are classified as *fluids*.

Liquids vary in the rate at which they spread. You know from experience that honey is thicker and flows more slowly than lemonade. This property, **viscosity**, is determined by the attraction between particles in a liquid. The stronger the attraction, the more slowly the liquid will flow, and the higher the viscosity will be.

viscosity the resistance of a fluid to flow

energy the ability to change or move matter

Energy's Role

What sources of energy would you use if the electricity was off? You might use candles for light and batteries to power a clock. Electricity, candles, and batteries are sources of energy. So is the food you eat. Substances that release heat when they are mixed together are another source of energy. You can think of **energy** as the ability to change or move matter. In Chapter 9, you will learn how energy can be described as the ability to do work.

Energy must be added to cause melting or evaporation

The first major step in the process of recycling aluminum cans is to melt the aluminum. Heating solid aluminum transfers energy to the aluminum atoms. As the atoms gain energy, they vibrate faster. Eventually, they break away from their fixed positions, and the aluminum melts, becoming a liquid. Energy is required to melt aluminum or any solid because the particles must break away from their fixed positions.

You can feel the effects of an energy change when you feel a breeze after you have been perspiring. Energy from your body's molecules is transferred as heat to the water on your skin. When this transfer occurs, your body's molecules cool off and slow down, while the water molecules gain energy and move faster, as shown in **Figure 2-13.**

Figure 2-13
Your body's heat provides the energy for sweat to evaporate.

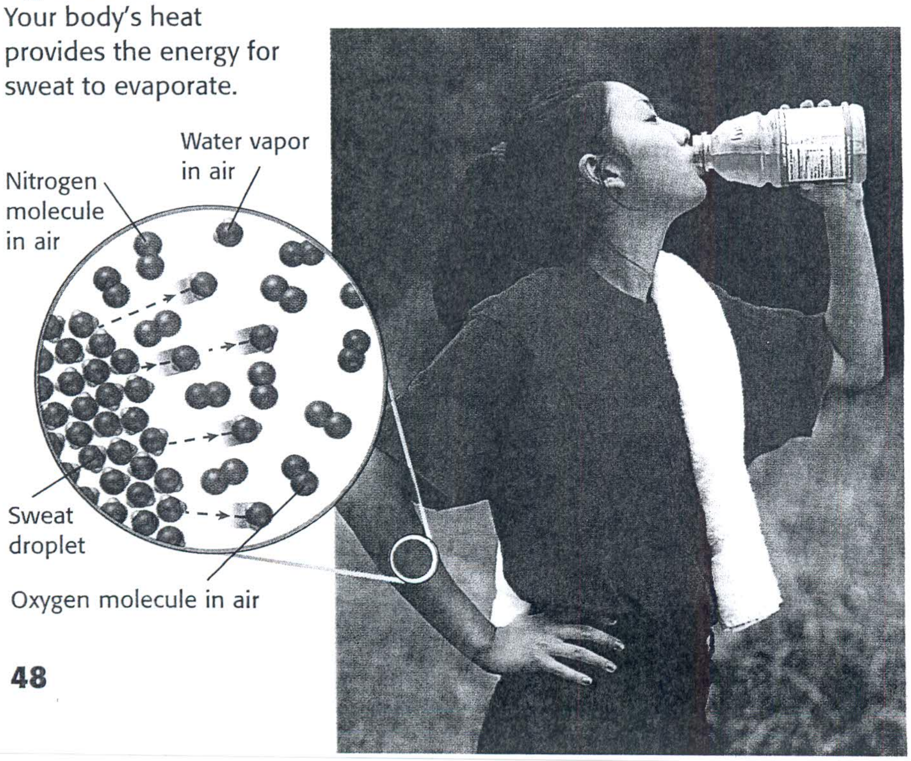
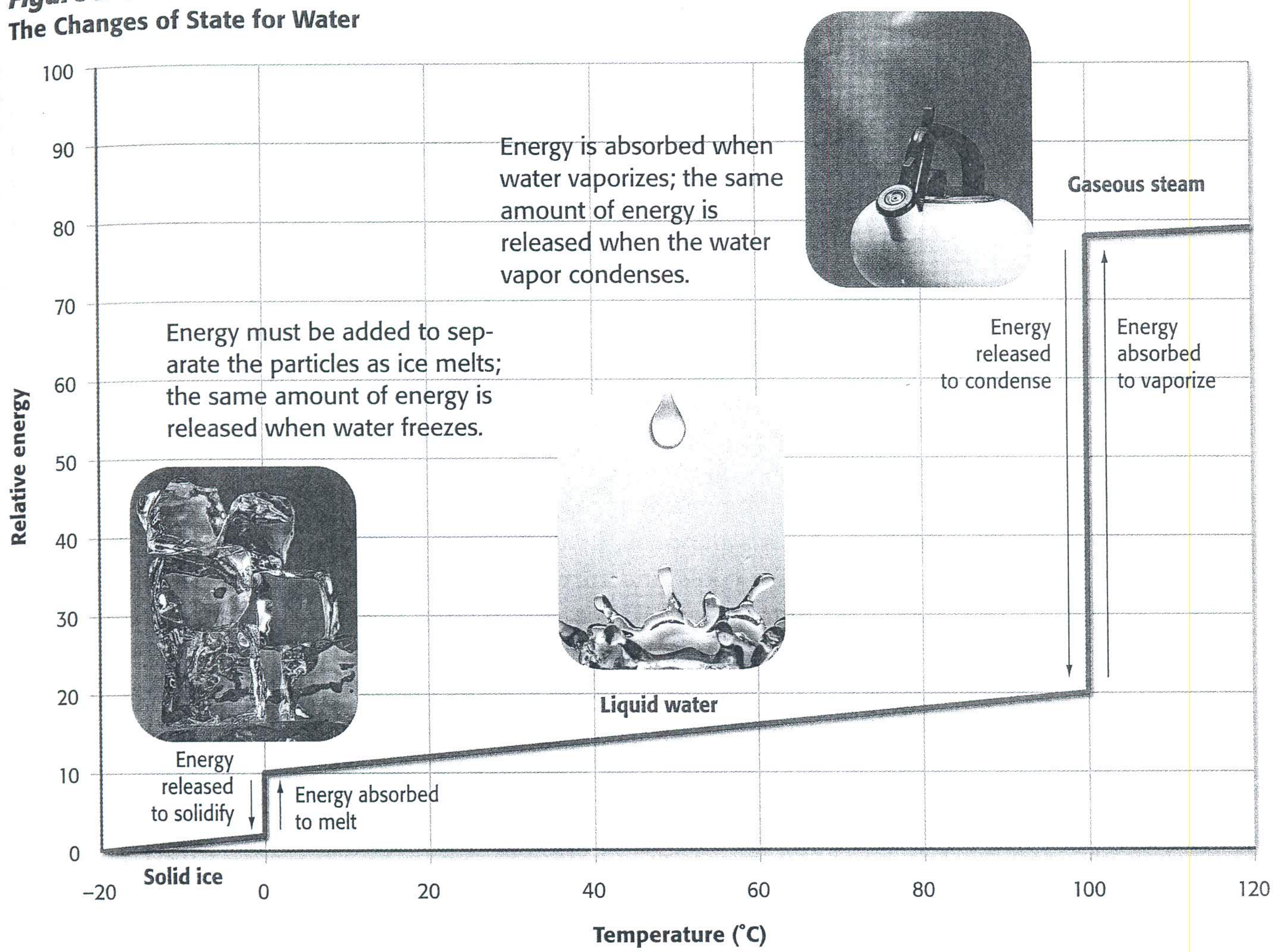


Figure 2-14
The Changes of State for Water



Eventually, the fastest moving molecules break away from the liquid surface to form a gas. The water is said to **evaporate.** It takes energy to separate the particles of a liquid to form a gas.

Evaporation occurs slowly when liquids are cool. But as the temperature of the liquid increases, more of the molecules gain enough energy to break away from the liquid surface and form a gas. If the liquid is heated enough, so many molecules become gas that bubbles form below the surface of the liquid and the liquid boils.

evaporation the change of a substance from a liquid to a gas

Energy is transferred in all changes of state

When water vapor **condenses** to become a liquid or liquid water freezes to form ice, energy is transferred from the water to its surroundings. The water molecules slow down during this energy transfer. The graph in **Figure 2-14** shows the energy transfers that occur as water changes among the three common states of matter.

condensation the change of a substance from a gas to a liquid

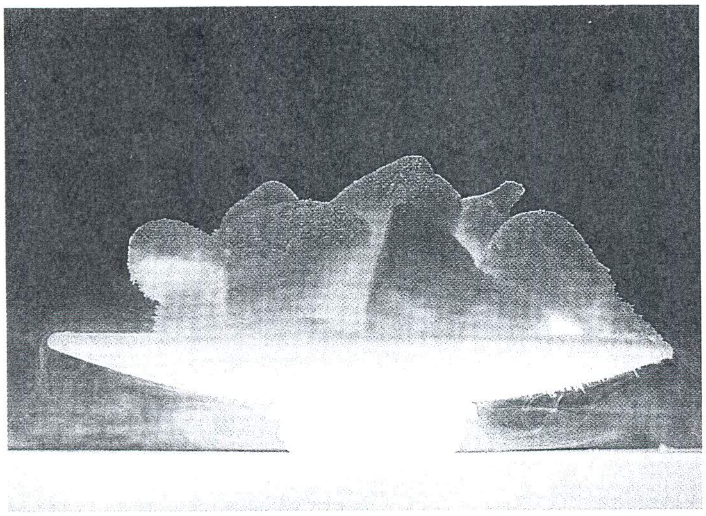


Figure 2-15
Dry ice (solid carbon dioxide) sublimes to form gaseous carbon dioxide but no liquid.

Some substances do not have a liquid form at normal temperature and pressure. **Figure 2-15** shows solid carbon dioxide, CO_2, undergoing **sublimation,** that is, turning directly into a gas without becoming a liquid. Sometimes, ice made of water molecules sublimes, forming a gas. When left in the freezer for a couple of months, ice cubes get smaller as the ice sublimes.

sublimation the change of a substance from a solid to a gas

Changing state does not change composition or mass

Heating or cooling can change the state of a substance. Look at the changes of state that are happening in **Figure 2-16.** Some of the steam is condensing. As this happens, heat is transferred to the surroundings, so the steam cools and turns back into liquid water. Changing the energy of a substance can change the state of the substance, but changing energy does not change the composition of a substance. Ice, water, and steam are all made of H_2O molecules. All that changes is the nature of the attractions between the molecules—strong in a solid and almost nonexistent in a gas.

When an ice cube melts, the mass of the liquid water is the same as the mass of the ice cube. Even though the ice underwent a physical change to produce the water, the mass was not increased or reduced. Similarly, when water boils, the number of water molecules stays the same even as the liquid water loses volume. The mass of the steam is the same as the mass of the liquid water that boiled off.

Figure 2-16
Whether it is ice, water, or steam, water in any form is always made of H_2O molecules.

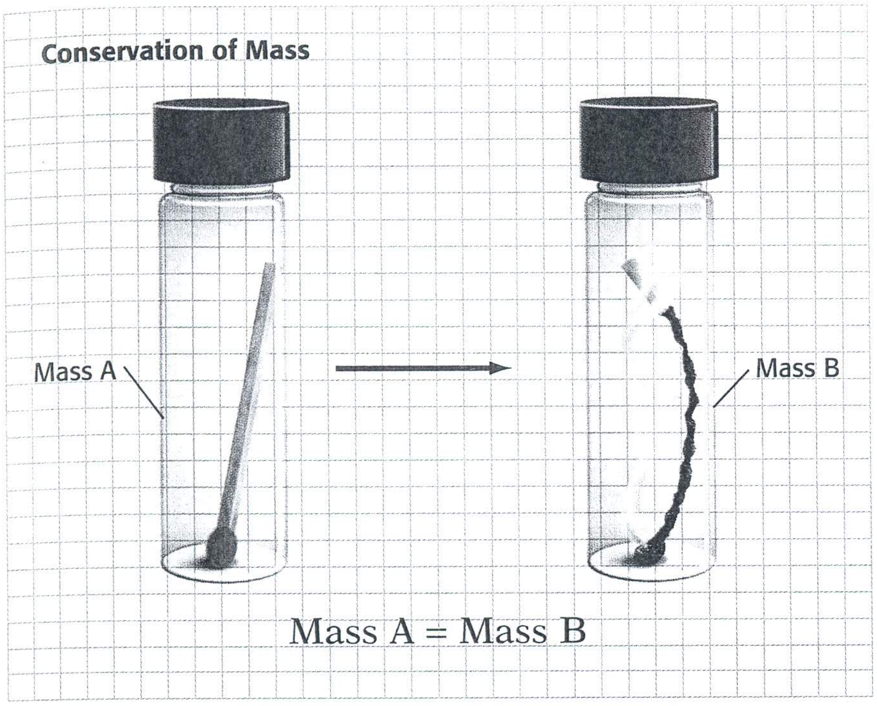


Figure 2-17
The match is changed by burning, but the masses of the reactants and the products are equal.

The law of conservation of mass

In chemical changes as well as in physical changes, the total mass of all matter stays the same before and after a change. Matter changes from one form to another, but the total mass stays the same. This is called the law of conservation of mass. The law of conservation of mass is stated as follows.

Mass cannot be created or destroyed.

When you burn a match, it seems to lose mass. The ash has less mass than the original match. But the burning reaction involves gases too, and gases have mass, even though they may be difficult to see or measure. There is also mass in the oxygen that reacts with the match, in the tiny particles that we see as smoke, and in the gases formed in the reaction. The total mass of the reactants (match and oxygen) is the same as the total mass of the products (ash, smoke, and gases), as you can see in **Figure 2-17.**

The law of conservation of energy

Although energy may be converted from one form to another during a physical or chemical change, the total amount of energy before and after the change is always the same. This is the law of conservation of energy, which can be stated as follows.

Energy cannot be created or destroyed.

The law of conservation of energy is described in more detail in Chapter 9.

INTEGRATING

SPACE SCIENCE
Studies of the chemical changes that stars and nebulae undergo are constantly adding to our knowledge. Present estimates are that hydrogen makes up more than 90 percent of the atoms in the universe and constitutes about 75 percent of the mass of the universe. Helium atoms make up most of the remainder. The total of all the other elements contributes very little to the total mass of the universe.

At first glance, starting a car may seem to violate this law. For the tiny amount of energy needed for a person to turn the key in the ignition, a lot of energy results. But the car needs gasoline to run. Gasoline releases energy when it is burned. Because of the arrangement of the atoms in the compounds that make up gasoline, gasoline has stored energy. When this stored energy is considered, the energy before you start the car is equal to the energy afterward.

When you drive a car, gasoline is burned to produce the energy needed to power the car. However, some of the energy from the gasoline is transferred to the surroundings as heat. That is why a car's engine gets hot. The total amount of energy released by the gasoline is equal to the energy used to move the car plus the energy transferred to the surroundings as heat.

When you study nuclear changes and radioactivity in Chapter 7, you will learn that the law of conservation of mass and the law of conservation of energy can be made into one law, which covers all the changes discussed here.

internetconnect

SCILINKS NSTA

TOPIC: States of matter
GO TO: www.scilinks.org
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SECTION 2.2 REVIEW

SUMMARY

- The kinetic theory assumes that all matter is made of tiny particles that are always moving.
- Solids have a fixed volume and shape.
- Gases have a variable volume and shape.
- Liquids have a fixed volume but variable shape.
- Pressure is the force exerted on the unit area of a surface.
- The viscosity of a fluid is its resistance to flow.
- Energy is the ability to heat, change, or move matter.
- Mass and energy are conserved in all changes.

CHECK YOUR UNDERSTANDING

1. **Define** *energy.*
2. **State** the law of conservation of mass and the law of conservation of energy.
3. **List** two examples for each of the three common states of matter.
4. **Rank** the following in order of increasing strength of forces between molecules:
   a. honey
   b. marble
   c. water
   d. candle wax
   e. nitrogen gas
5. **Compare and Contrast** the shape and volume of solids, liquids, and gases.
6. **Predict** which two of the following involve the same energy transfer. Assume that the same substance and the same mass is involved in all four processes.
   a. melting
   b. evaporation
   c. sublimation
   d. condensation
7. **Describe** the energy transfers that occur when ice melts and water vapor condenses to form liquid water. Portray each state of matter and the change of state, using a computer-drawing program. COMPUTER SKILL
8. **Creative Thinking** Describe a characteristic of gases, and use the kinetic theory to explain how a dog could find you by your scent.